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DESCRIPTION

Component Recognizing Method and Apparatus and Component Mounting Method and Apparatus

Technical Field

The present invention relates particularly to component recognizing method and apparatus for recognizing components prior to the installation of the components on objects to be installed such as boards and components and to component mounting method and apparatus for installing the recognized components on the objects such as boards and components, in component mounting equipment for mounting components such as electronic components and optical components.

Background Art

As a head unit having suction nozzles for sucking and holding components in such a component mounting apparatus, for example, such a head unit 700 as shown in FIG. 3 has been known conventionally. In such a component mounting apparatus 500 as shown in FIG. 24, for example, the head unit 1700 is installed in an X-Y robot 500X for moving the head unit 700 in X-Y directions, suction nozzles of the head unit 700 driven by the X-Y robot 500X suck and hold components fed from component feeding units 500H and

500I for the production of a mounted board 500J and, after the recognition of the shapes of the components and the correction of the postures thereof, the head unit mounts the components on the board 500J. Reference character 500M in FIG. 24 denotes a motor that drives the head unit 700 in the direction of Y axis of the X-Y robot 500X and, in the movement in the direction of Y axis, components sucked and held by the suction nozzles are moved over a recognition camera and recognized.

Such a head unit 770 as shown in FIG. 5 also has been known and the head unit 770 has a configuration and a function which are similar to those of the head unit 700 of FIG. 3.

Hereinbelow, the configurations of the head units 700 and 770 will be described.

In FIG. 3, reference numeral 701 denotes a frame that serves as a foundation of the head unit 700, and the frame moves above the component mounting apparatus in combination with the robot unit that drives the head unit 700 in the X-Y directions of the component mounting apparatus. Reference numeral 702 denotes a motor that is a drive source and is integral with the frame, and thus a table 703 is moved in directions E and F, i.e., in vertical directions. Reference numerals 724 to 733 denote nozzles which suck and hold components and the nozzles 724 to 733

are normally biased by springs 714 to 723 in a direction E so as to stand still. Reference numerals 704 to 713 denote cylinders which selectively transmit drives from the table 703 to the nozzles 724 to 733 in the directions E and F. Among the cylinders 704 to 713, only the cylinders corresponding to the nozzles to which actions are to be transmitted from the table 703 are driven to come into contact with only those nozzles (among the nozzles 724 to 733) to effect forces in the direction E so that the vertical movement of the table 703 causes movements of the selected nozzles in the directions E and F through the actions of the driven cylinders. On the contrary, among the cylinders 704 to 713, the cylinders which do not transmit the movements in the directions E and F are not driven and do not come into contact with the nozzles 704 to 713 and therefore do not cause the movements in the directions E and F.

Hereinbelow, the movement of the head unit 700 configured as above will be described. In FIGS. 4A to 4C, only four nozzles 724, 725, 726, and 727 out of the ten nozzles are shown for brevity.

At the commencement of recognition in FIG. 4A, for example, four nozzles 724, 725, 726, and 727 out of the ten nozzles simultaneously descend to a specified height while holding components 695, 696, 697, and 698, and the

component 695, then the component 696, then the component 697 and then the component 698 are subsequently recognized in order of mention in accordance with a direction R of a movement of the head unit 700, with a recognition camera 600, i.e., a component shape recognition unit. At this time, the focus of the recognition camera 600 is obtained in a diagonally shaded range P in FIG. 4A and the recognition can be achieved only in the range P. The bottom surfaces of the components 695, 696, and 697 can be positioned in the recognizable range P through the vertical movements of the nozzles 724, 725, and 726 and can be recognized with the recognition camera 600. On the other hand, the bottom surface of the component 698 is out of the recognizable range P and cannot be recognized with the recognition camera 600. Accordingly, the shapes of components having different heights such as the components 695, 696, and 697 and the component 698 cannot be recognized continuously, for example, in the order of the component 695, then the component 696, then the component 697 and then the component 698.

In practice, as shown in FIG. 4B, the shapes of the components 695, 696, and 697 which are held by the nozzles 724, 725, and 726 and can be simultaneously recognized are continuously recognized. After that, the component 698 is held by the nozzle 727 and then the height

of the nozzle 727 relative to the recognition camera 600 is switched and the component 698 is recognized.

The configuration of the head unit 770 shown in FIG. 5 will be described below.

Reference numeral 771 denotes a frame that serves as a foundation of the head unit 770 and the frame 771 is integral with motors 772, 773, and 774 which are drive sources. Numerals 775, 776, and 777 denote ball screws which are rotated individually by the motors 772, 773, and 774, respectively, and numerals 778, 779, and 780 denote nozzles for holding components. Rotational drive caused by the motors 772, 773, and 774 is transmitted to the nozzles 778, 779, and 780 through the medium of the ball screws 775, 776, and 777 so as to move the nozzles vertically. As a result, the settings of the vertical movements of the nozzles 778, 779, and 780 can be individually provided by the motors 772, 773, and 774.

Hereinbelow, the movement of the head unit 770 configured as above will be described.

In FIG. 6, drives of the nozzles 778, 779, and 780 in directions U and V, i.e., in upward and downward directions in FIG. 5 are individually controlled by the motors 772, 773, and 774. Thus, components 787, 788, and 789 are held respectively and then positions of the components are individually adjusted so that bottom

surfaces of the components come into a recognizable range P in which the focus of a component shape recognition unit 600 is obtained. In this manner, shape recognition and mounting of the components 787, 788, and 789 having different heights are performed continuously in the order of the component 787, then the component 788, and then the component 789.

On the other hand, such a configuration of the head unit 700 as mentioned above with reference to FIG. 3 causes an increase in the number of times of component shape recognition with an increase in the variety of heights of components to be mounted and, at the same time, causes an increase in the transit time of the head unit 700 for the feeding of the components, so that an increase in tact time for the mounting on boards influences the productivity of mounted boards.

In recent years, however, the need for the mounting of various types of components has increased and component mounting apparatus which are capable of recognizing various components continuously have been essential for board mounting with high efficiency.

With such a configuration of the head unit 770 as mentioned above with reference to FIG. 5, shapes of components can be continuously recognized regardless of a difference in the heights of the components; however, the

necessity for a plurality of drive sources not only raises the cost of the head unit itself but may exert an influence on dynamic characteristics of a robot for driving the head unit because of an increase in the weight of the head unit and other influences. This results in the limitation on the number of nozzles, which may inhibit the improvement in the efficiency of component mounting.

It is an object of the present invention to solve the above-mentioned issues, that is, to provide component recognizing method and apparatus and component mounting method and apparatus by which components with various heights held by a plurality of component holding members can be recognized continuously.

Disclosure Of Invention

In order to achieve the above-mentioned object, the present invention is configured as will be described below.

According to a first aspect of the present invention, there is provided a component recognizing method for recognizing with one recognition unit surfaces to be recognized of a plurality of components held by a plurality of component holding members which are vertically moved selectively by a single drive unit and having the surfaces to be recognized of different heights, in which heights of

the component holding members are controlled so as to bring the surface to be recognized of each of the plurality of components into a recognizable range of the recognition unit and the surfaces to be recognized of the plurality of components are continuously recognized.

According to a second aspect of the present invention, there is provided a component recognizing method as defined in the first aspect, wherein the plurality of components held by the plurality of component holding members and having the surfaces to be recognized of different heights have such a variation in height that not all the surface to be recognized of the plurality of components are within the recognizable range of the recognition unit when bottom end surfaces of the plurality of component holding members are situated at an identical height.

According to a third aspect of the present invention, there is provided a component recognizing method as defined in the second aspect, wherein, among the plurality of components held by the plurality of component holding members and having the surfaces to be recognized of different heights which components have such a variation in height that not all the surface to be recognized of the plurality of components are within the recognizable range of the recognition unit when the bottom end surfaces of the

plurality of component holding members are situated at an identical height, components of which the surfaces to be recognized are within the recognizable range of the recognition unit are recognized without a selective vertical movement of component holding members holding the components by drive of the single drive unit and without a change in heights of the surfaces, and components of which the surfaces to be recognized are out of the recognizable range of the recognition unit are recognized so that the surfaces to be recognized are recognized after a positioning operation with a vertical movement of component holding members holding the components is controlled so as to bring the surfaces to be recognized into the recognizable range of the recognition unit.

According to a fourth aspect of the present invention, there is provided a component recognizing method as defined in any one of the first to third aspects, wherein shapes of the components are recognized when the surfaces to be recognized of the components are recognized.

According to a fifth aspect of the present invention, there is provided a component recognizing apparatus for recognizing with one recognition unit surfaces to be recognized of a plurality of components held by a plurality of component holding members which are vertically moved selectively by a single drive unit and

having the surfaces to be recognized of different heights, heights of the component holding members are adapted to be controlled so as to bring the surface to be recognized of each of the plurality of components into a recognizable range of the recognition unit and continuously recognizes the surfaces to be recognized of the plurality of components.

According to a sixth aspect of the present invention, there is provided a component recognizing apparatus as defined in the fifth aspect, wherein the plurality of components held by the plurality of component holding members and having the surfaces to be recognized of different heights have such a variation in height that not all the surface to be recognized of the plurality of components are within the recognizable range of the recognition unit when bottom end surfaces of the plurality of component holding members are situated at an identical height.

According to a seventh aspect of the present invention, there is provided a component recognizing apparatus as defined in the sixth aspect, wherein, among the plurality of components held by the plurality of component holding members and having the surfaces to be recognized of different heights which components have such a variation in height that not all the surface to be recognized

recognized of the plurality of components are within the recognizable range of the recognition unit when the bottom end surfaces of the plurality of component holding members are situated at an identical height, components of which the surfaces to be recognized are within the recognizable range of the recognition unit are recognized without a selective vertical movement of component holding members holding the components by drive of the single drive unit and without a change in heights of the surfaces, and components of which the surfaces to be recognized are out of the recognizable range of the recognition unit are recognized so that the surfaces to be recognized are recognized after a positioning operation with a vertical movement of component holding members holding the components is controlled so as to bring the surfaces to be recognized into the recognizable range of the recognition unit.

According to an eighth aspect of the present invention, there is provided a component recognizing apparatus as defined in any one of the fifth to seventh aspects, wherein shapes of the components are adapted to be recognized when the surfaces to be recognized of the components are recognized.

According to a ninth aspect of the present invention, there is provided a component mounting apparatus comprising:

a single drive unit;

a plurality of component holding members which are adapted to be vertically moved selectively by the single drive unit and hold a plurality of components;

a head unit including the single drive unit and the plurality of component holding members; and

one recognition unit which is adapted to recognize surfaces to be recognized of the plurality of components held by the plurality of component holding members when the surfaces to be recognized are within a recognizable range,

wherein heights of the component holding members is adapted to be controlled so as to bring the surface to be recognized of each of the plurality of components into the recognizable range of the recognition unit and continuously recognizes the surfaces to be recognized of the plurality of components, when the surfaces to be recognized of the plurality of components held by the plurality of component holding members and having the surfaces to be recognized of different heights are recognized with the one recognition unit while the head unit is moving.

According to a 10th aspect of the present invention, there is provided a component mounting apparatus as defined in the ninth aspect, wherein the plurality of components held by the plurality of component holding

members and having the surfaces to be recognized of different heights have such a variation in height that not all the surface to be recognized of the plurality of components are within the recognizable range of the recognition unit when bottom end surfaces of the plurality of component holding members are situated at an identical height.

According to an 11th aspect of the present invention, there is provided a component mounting apparatus as defined in the ninth aspect, wherein, among the plurality of components held by the plurality of component holding members and having the surfaces to be recognized of different heights which components have such a variation in height that not all the surface to be recognized of the plurality of components are within the recognizable range of the recognition unit when the bottom end surfaces of the plurality of component holding members are situated at an identical height, components of which the surfaces to be recognized are within the recognizable range of the recognition unit are recognized without a vertical movement of component holding members holding the components and without a change in heights of the surfaces, and components of which the surfaces to be recognized are out of the recognizable range of the recognition unit are recognized so that the surfaces to be recognized are recognized with the

recognition unit after a positioning operation with a selective vertical movement of component holding members holding the components by drive of the single drive unit is controlled so as to bring the surfaces to be recognized into the recognizable range of the recognition unit.

According to a 12th aspect of the present invention, there is provided a component mounting apparatus as defined in any one of the ninth to eleventh aspects, wherein shapes of the components are adapted to be recognized when the surfaces to be recognized of the components are recognized.

According to a 13th aspect of the present invention, there is provided a component mounting apparatus as defined in any one of the ninth to 12th aspects, further comprising: a table which is adapted to be vertically moved by the single drive unit; and cylinders which are fixed to the table, corresponding to the component holding members, and is adapted to bring a tip of a piston into contact with only the component holding member selected so as to be vertically moved among the plurality of component holding members and thereby transmit vertical movement of the table to the selected component holding member.

According to a 14th aspect of the present invention, there is provided a component recognizing method as defined in any one of the first to fourth aspects,

further comprising:

producing a velocity curve in vertical movement of the selected component holding member with parameters of a target position in a direction of height at time when the vertical movement of the selected component holding member is controlled by means of the drive unit so as to position the surface to be recognized of a component within the recognizable range of the recognition unit, a maximum velocity in the vertical movement of the selected component holding member up to the target position, and a maximum acceleration in the vertical movement of the selected component holding member up to the target position, and

automatically starting a positioning operation, into the recognizable range, of the surface to be recognized of the component held by the selected component holding member driven by the drive unit on a basis of the velocity curve in response to a positioning operation starting instruction upon arrival at a positioning operation starting position of the selected component holding member moving transversely toward the recognition unit.

According to a 15th aspect of the present invention, there is provided a component recognizing method as defined in the 14th aspect, wherein a plurality of sets of parameters of the target positions and the positioning operation starting positions are provided and continuous

positioning operations are thereby executed with provision of a plurality of timings.

According to a 16th aspect of the present invention, there is provided a component recognizing method as defined in the 15th aspect, further comprising, with a plurality of positioning operation ending positions corresponding to the plurality of positioning operation starting positions provided, judging whether individual positioning operations in continuous positioning operations which were started at the plurality of positioning operation starting positions have reached the respective positioning operation ending positions or not so as to detect whether the respective positioning operations have been done normally or not.

According to a 17th aspect of the present invention, there is provided a component recognizing apparatus as defined in any one of the fifth to eighth aspects, comprising:

a first control unit which is adapted to produce a velocity curve in vertical movement of the selected component holding member with parameters of a target position in a direction of height at time when the vertical movement of the selected component holding member is controlled by means of the drive unit so as to position the surface to be recognized of a component within the

recognizable range of the recognition unit, a maximum velocity in the vertical movement of the selected component holding member up to the target position, and a maximum acceleration in the vertical movement of the selected component holding member up to the target position; and

a second control unit which is adapted to drive the drive unit in response to a positioning operation starting instruction and automatically start a positioning operation of the selected component holding member driven by the drive unit on a basis of the velocity curve, upon arrival at a positioning operation starting position of the selected component holding member moving transversely toward the recognition unit.

According to an 18th aspect of the present invention, there is provided a component recognizing apparatus as defined in the 17th aspect, wherein a plurality of sets of parameters of the target positions and the positioning operation starting positions are provided and thereby the second control unit is adapted to execute continuous positioning operations with provision of a plurality of timings.

According to a 19th aspect of the present invention, there is provided a component recognizing apparatus as defined in the 18th aspect, wherein with a plurality of positioning operation ending positions

corresponding to the plurality of positioning operation starting positions provided, the second control unit is adapted to judge whether individual positioning operations in continuous positioning operations which were started at the plurality of positioning operation starting positions have reached the respective positioning operation ending positions or not and thereby detects whether the respective positioning operations have been done normally or not.

According to a 20th aspect of the present invention, there is provided a component mounting apparatus as defined in the ninth aspect, wherein the single drive unit is a single motor, and the single motor is adapted to drive a ball screw to rotate and thereby vertically moves a table that is in screw engagement with the ball screw,

the apparatus further comprising: cylinders which are fixed to the table, corresponding to the component holding members, and is adapted to bring a tip of a piston into contact with only the component holding member selected so as to be vertically moved among the plurality of component holding members and thereby transmit vertical movement of the table to the selected component holding members;

a first control unit which is adapted to produce a velocity curve in vertical movement of the selected component holding members by means of the single motor,

with parameters of a target position in a direction of height at time when the vertical movement of the selected component holding members is controlled by means of the single motor so as to position the surface to be recognized of a component within the recognizable range of the recognition unit, a maximum velocity in the vertical movement of the selected component holding members up to the target position, and a maximum acceleration in the vertical movement of the selected component holding members up to the target position; and

a second control unit which is adapted to drive the single motor in response to a positioning operation starting instruction and automatically start positioning operations of the selected component holding members driven by the single motor on a basis of the velocity curve, upon arrival at a positioning operation starting position of the selected component holding members moving with the head unit transversely toward the recognition unit.

According to a 21st aspect of the present invention, there is provided a component mounting apparatus as defined in the 20th aspect, further comprising a transverse movement motor for moving the component holding members in transverse direction, wherein

the first control unit is further adapted to produce a velocity curve in transverse movement of the

selected component holding members by means of the transverse movement motor, with parameters of a target position in transverse direction at time when the transverse movement of the selected component holding members up to vertical drive starting positions for the selected component holding members is controlled by means of the transverse movement motor, for recognition of the surface to be recognized of a component within the recognizable range of the recognition unit, a maximum velocity in the transverse movement of the selected component holding members up to the target position, and a maximum acceleration in the transverse movement of the selected component holding members up to the target position, and

the second control unit is adapted to drive the transverse movement motor in response to the positioning operation starting instruction and automatically start positioning operations of the selected component holding members driven by the transverse movement motor on the basis of the velocity curve, upon arrival at the positioning operation starting position of the selected component holding members moving with the head unit transversely toward the recognition unit.

According to a 22nd aspect of the present invention, there is provided a component mounting method in

which the plurality of components from component feeding units are held by the plurality of component holding members, the components are thereafter recognized with the component recognizing method as defined in any one of the first to fourth and 14th to 16th aspects, postures of the plurality of components held by the plurality of component holding members are thereafter corrected on a basis of a recognition result, and the components are thereafter installed on an object to be installed.

According to a 23rd aspect of the present invention, there is provided a component mounting apparatus which is adapted to hold the plurality of components from component feeding units by the plurality of component holding members, thereafter recognize the components with the recognition unit of the component recognizing apparatus as defined in any one of the fifth to eighth and 17th to 19th aspects, thereafter correct postures of the plurality of components held by the plurality of component holding members on a basis of a recognition result, and thereafter install the components on an object to be installed.

According to a 24th aspect of the present invention, there is provided a component recognizing method as defined in the first aspect, wherein

after the plurality of component holding members holding the plurality of components having the surfaces to

be recognized of different heights are moved in one direction over the one recognition unit, the plurality of component holding members are moved in a reverse direction opposite to the one direction over the one recognition unit with heights of the plurality of component holding members changed, and

all the plurality of components held by the plurality of component holding members are imaged with the recognition unit in respective movement of the plurality of component holding members in the one direction and in the reverse direction, and the surfaces to be recognized of only components having the surfaces to be recognized brought into the recognizable range of the recognition unit among the plurality of components are recognized.

According to a 25th aspect of the present invention, there is provided a component recognizing method as defined in the first aspect, wherein

the plurality of component holding members holding the plurality of components having the surfaces to be recognized of different heights are moved in one direction over the one recognition unit and the surfaces to be recognized of only components having the surfaces to be recognized brought into the recognizable range of the recognition unit among the plurality of components held by the plurality of component holding members are recognized,

and

heights of the plurality of component holding members are changed and the plurality of component holding members are thereafter moved in a reverse direction opposite to the one direction over the one recognition unit and the surfaces to be recognized of only components having the surfaces to be recognized brought into the recognizable range of the recognition unit among the plurality of components held by the plurality of component holding members are recognized.

According to a 26th aspect of the present invention, there is provided a component recognizing method as defined in the first aspect, wherein

the plurality of component holding members holding the plurality of components having the surfaces to be recognized of different heights are moved over the one recognition unit and the surfaces to be recognized of only components having the surfaces to be recognized brought into the recognizable range of the recognition unit among the plurality of components held by the plurality of component holding members are recognized, and

heights of the plurality of component holding members are changed and the plurality of component holding members are thereafter moved over a recognition unit other than the one recognition unit and the surfaces to be

recognized of only components having the surfaces to be recognized brought into the recognizable range of the recognition unit among the plurality of components held by the plurality of component holding members are recognized.

According to a 27th aspect of the present invention, there is provided a component recognizing apparatus as defined in the fifth aspect, further comprising a control unit which is adapted to move the plurality of component holding members holding the plurality of components having the surfaces to be recognized of different heights in one direction over the one recognition unit, thereafter move the plurality of component holding members in a reverse direction opposite to the one direction over the one recognition unit with heights of the plurality of component holding members changed, perform imaging with the recognition unit of all the plurality of components held by the plurality of component holding members in respective movement of the plurality of component holding members in the one direction and in the reverse direction, and recognize the surfaces to be recognized of only components having the surfaces to be recognized brought into the recognizable range of the recognition unit among the plurality of components.

According to a 28th aspect of the present invention, there is provided a component recognizing

apparatus as defined in the fifth aspect, further comprising a control unit which is adapted to move the plurality of component holding members holding the plurality of components having the surfaces to be recognized of different heights in one direction over the one recognition unit, recognize the surfaces to be recognized of only components having the surfaces to be recognized brought into the recognizable range of the recognition unit among the plurality of components held by the plurality of component holding members, move the plurality of component holding members in a reverse direction opposite to the one direction over the one recognition unit after changing heights of the plurality of component holding members, and recognize the surfaces to be recognized of only components having the surfaces to be recognized brought into the recognizable range of the recognition unit among the plurality of components held by the plurality of component holding members.

According to a 29th aspect of the present invention, there is provided a component recognizing apparatus as defined in the fifth aspect, further comprising: another recognition unit capable of recognizing surfaces to be recognized of components having heights of the surfaces to be recognized different from those of components which are recognized by means of the one

recognition unit; and

a control unit which is adapted to move the plurality of component holding members holding the plurality of components having the surfaces to be recognized of different heights over the one recognition unit, recognize the surfaces to be recognized of only components having the surfaces to be recognized brought into the recognizable range of the recognition unit among the plurality of components held by the plurality of component holding members, move the plurality of component holding members over the another recognition unit other than the one recognition unit after changing heights of the plurality of component holding members, and recognize the surfaces to be recognized of only components having the surfaces to be recognized brought into the recognizable range of the another recognition unit among the plurality of components held by the plurality of component holding members.

According to a 30th aspect of the present invention, there is provided a component recognizing method comprising:

moving a plurality of component holding members holding a plurality of components having surfaces to be recognized of different heights in one direction over a recognition unit, thereafter moving the plurality of component holding members in a reverse direction opposite

to the one direction over the recognition unit with heights of the plurality of component holding members changed; and

recognizing the surfaces to be recognized of components having the surfaces to be recognized brought into the recognizable range of the recognition unit among the plurality of components held by the plurality of component holding members in respective movement of the plurality of component holding members in the one direction and in the reverse direction.

According to a 31st aspect of the present invention, there is provided a component recognizing apparatus comprising:

a plurality of component holding members which is adapted to hold a plurality of components having surfaces to be recognized of different heights;

a recognition unit over which the plurality of component holding members are capable of moving in one direction and in a reverse direction opposite to the one direction and, after moved in the one direction, are moved in the reverse direction opposite to the one direction with heights of the plurality of component holding members changed and which is adapted to perform imaging of all the plurality of components held by the plurality of component holding members in respective movement of the plurality of component holding members in the one direction and in the

reverse direction; and

a control unit which is adapted to recognize the surfaces to be recognized of only components having the surfaces to be recognized brought into a recognizable range of the recognition unit among the plurality of components.

Brief Description Of Drawings

These and other aspects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of a component mounting apparatus showing a first embodiment of the present invention;

FIGS. 2A, 2B, 2C and 2D are explanatory drawings for explaining a positioning operation mode of the component mounting apparatus of FIG. 1;

FIG. 3 illustrates a prior art 1 and is a perspective view of a component mounting apparatus;

FIGS. 4A, 4B and 4C are explanatory drawings for explaining a positioning operation mode of the component mounting apparatus;

FIG. 5 illustrates a prior art 2 and is a perspective view of a component mounting apparatus;

FIG. 6 is an explanatory drawing for explaining a positioning operation mode of the component mounting apparatus;

FIG. 7 is a general perspective view of component mounting equipment showing an embodiment of the present invention;

FIGS. 8A, 8B, 8C, 8D, 8E, 8F and 8G are views illustrating examples of components to be recognized;

FIG. 9 is a block diagram illustrating a positioning control configuration of a component mounting apparatus according to a second embodiment of the present invention;

FIG. 10 is a diagram illustrating output on instructive velocities in the component mounting apparatus according to the second embodiment of the present invention;

FIG. 11 is a flow chart of positioning operations in the component mounting apparatus according to the second embodiment of the present invention;

FIG. 12 is a flow chart of positioning operations in a component mounting apparatus according to a modification of the second embodiment;

FIG. 13 is a flow chart of positioning operations in a component mounting apparatus according to another modification of the second embodiment;

FIG. 14 is a diagram illustrating output on instructive velocities in the positioning operations of FIGS. 12 and 13;

FIG. 15 is a diagram of configuration of a conventional system;

FIG. 16 is a diagram illustrating output on instructive velocities in the conventional system;

FIG. 17 is a view illustrating an example of a mechanical device;

FIG. 18 is a view illustrating an example of a mechanical device;

FIGS. 19A and 19B are views illustrating an example of a system for recognizing a component while moving the component;

FIG. 20 is a diagram illustrating a basic configuration that is required for component recognition processes in an electronic component mounting apparatus of a third embodiment of the present invention;

FIG. 21 is a diagram illustrating a basic configuration that is required for component recognition processes in an electronic component mounting apparatus of a fourth embodiment of the present invention;

FIG. 22 is a diagram illustrating a basic configuration that is required for component recognition processes in an electronic component mounting apparatus;

FIG. 23 is a perspective view of a head unit of the electronic component mounting apparatus of the third and the fourth embodiments;

FIG. 24 is a general perspective view of component mounting equipment showing a prior art;

FIG. 25 is a block diagram illustrating relations between a control unit and a drive device and the like in the component mounting apparatus of the first embodiment and the second embodiment;

FIG. 26 is a block diagram illustrating relations between a control unit and a drive device and the like in the component mounting apparatus of the third embodiment and the fourth embodiment;

FIG. 27 is a flow chart of recognizing operations in the third embodiment; and

FIG. 28 is an explanatory drawing for explaining a positioning operation mode according to another embodiment of the present invention.

Best Mode for Carrying Out the present invention

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

Embodiments of the present invention will now be

described in detail with reference to the drawings.

First Embodiment:

Hereinbelow, component recognizing method and apparatus and component mounting method and apparatus according to a first embodiment of the present invention will be described with reference to the drawings.

FIG. 1 illustrates the component mounting apparatus of the first embodiment of the present invention.

In FIG. 1, reference numeral 1 denotes a frame that serves as a foundation of a head unit 60 and the frame 1 is attached to a robot for driving the head unit and moves accompanying the robot. Numeral 2 denotes a vertical drive motor that is attached to the frame 1 and serves as a drive source. Numeral 3 denotes a table that is engaged with a rotating shaft composed of a ball screw of the motor 2 and moves vertically, i.e., in a direction A or a direction B relative to the frame 1 with a forward or reverse rotation of the rotating shaft of the motor 2, and the table 3 can be controlled so as to halt in an arbitrary position within a movable scope thereof. The table 3 corresponds to an L-type plate 318 shown in FIG. 23 that will be mentioned below, and the table 3 is provided with a screwing portion which is similar to a screwing portion 317 provided in the L-type plate 318, and the screwing portion of the table 3 is engaged with the rotating shaft composed

of the ball screw of the motor 2 so that the table 3 is moved up and down with a forward or reverse rotation of the rotating shaft of the motor 2 through the screwing portion of the table 3. Numerals 4 to 13 denote first to tenth cylinders which are fixed to the table 3 and function as drive transmitting units for selecting the transmission of the vertical movement of the table 3. Numerals 24 to 33 denote first to tenth nozzles which are supported by the frame 1 and have top ends capable of coming into contact with pistons of the first to tenth cylinders 4 to 13 upon the movement of the pistons to their lowest positions and suck and hold components to be installed. Numerals 14 to 23 denote first to tenth springs which continuously bias the first to tenth nozzles 24 to 33 in a downward direction, i.e., in the direction A and make the nozzles stand still.

A configuration of the component mounting apparatus 500 in which the head unit 60 is installed is shown in FIG. 7.

In such a component mounting apparatus 500 as shown in FIG. 7, for example, the head unit 60 is installed on an X-Y robot 500X for moving the head unit 60 in X-Y directions, and suction nozzles of the head unit 60 driven by the X-Y robot 500X suck and hold components fed from component feeding units 500H and 500I for the production of a mounted board 500J and, after the recognition of shapes

of the components and the correction of postures thereof, mount the components on the board 500J. Reference numeral 95 in FIG. 7 denotes a head unit driving motor which drives the head unit 60 in the direction of Y axis of the X-Y robot 500X (in the direction of an arrow N in which the head unit moves (transverse direction)) so as to move the head unit, e.g., at constant velocity as will be mentioned below. In the movement in the direction of Y-axis, components sucked and held by the suction nozzles, i.e., the first to tenth nozzles 24 to 33 are moved over a recognition camera 61 that will be mentioned below, and the components are recognized.

FIG. 25 shows relations between a control unit and a drive device and the like in the component mounting apparatus of the first embodiment. In FIG. 25, reference numeral 90 denotes a memory for image processing that captures both image data of components temporarily, numeral 91 denotes a memory for mounting that is stored with information including component data such as type, thickness, width, length, and weight of components used in component mounting, mounting order in the suction and the like of components, types of nozzles installed in the head unit, and relations between the types of nozzles and the types of components (in other words, information instructing which nozzle may suck which component), numeral

96 denotes an image processing unit that performs recognition processing while controlling the recognition camera 61, numeral 101 denotes a main controller as an example of the control unit. The main controller occasionally controls the image processing unit 96 and various drive devices or members such as the motor 2 and the head unit driving motor 95 and calculates a quantity of correction to a positional offset of an electronic component relative to a position in which the electronic component is to be sucked by a nozzle, from a result of recognition processing obtained from the image processing unit 96. The main controller 101 also controls various mounting operations such as feeding, suction, recognition, and installation of components throughout the component mounting apparatus. Reference numeral 89 in FIG. 25 denotes a nozzle suction device that controls sucking operations of the nozzles.

Hereinbelow, operations of the head unit 60 of the component mounting apparatus of the first embodiment under the control of the main controller 101 will be described with reference to FIGS. 2A, 2B, 2C, and 2D. In FIGS. 2A, 2B, 2C, and 2D, only four nozzles out of ten, i.e., the first to fourth nozzles 24, 25, 26, and 27 among the first to tenth nozzles 24 to 33 are shown for brevity.

In the head unit 60, forward or reverse

rotational drive of the rotating shaft of the motor 2 provided on the fixed frame 1 moves the table 3 vertically, motive power of the vertical movement is transmitted to nozzles corresponding to selected cylinders among the first to tenth nozzles 24 to 33 and the corresponding nozzles move vertically in response to the movement of the table 3, because driving forces of the selected cylinders among the first to tenth cylinders 4 to 13 overcome reactive forces of springs corresponding to the selected cylinders among the first to tenth springs 14 to 23 in upward direction, i.e., in a direction B. To be more specific, in the case that the eighth nozzle 31 is moved vertically with the vertical movement of the table 3 as shown in FIG. 1, for example, the eighth cylinder 11 is driven to cause the bottom surface of the piston thereof to be in contact with the top end of the eighth nozzle 31 and then the vertical movement of the table 3 causes the piston of the eighth cylinder 11 and the eighth nozzle 31 to move vertically as one body against the reactive force of the eighth spring 21. Nozzles corresponding to the cylinders not selected, i.e., nozzles to which the drive is not transmitted are not subjected to the transmission of the vertical movement of the table 3 and stand still in the same positions.

In FIG. 2A, the first to fourth nozzles 24, 25, 26, and 27 hold components 56, 57, 58, and 59 having

different heights and fed from component feeding units such as component feeding cassettes, and shapes, positions, and the like of the components are recognized with the recognition camera 61 as an example of a recognition unit in the order of the component 56, then the component 57, then the component 58, and then the component 59 while the head unit driving motor 95 (see FIG. 2A) in the robot for driving the head unit drives the head unit 60 to move continuously, e.g., at constant velocity in the direction of the arrow N in which the head unit moves (transverse direction). At this time, in order that a surface to be recognized, e.g., the bottom surface of the components 56 of which the shape is to be firstly recognized may come into a recognizable range L at the commencement of the recognition, the table 3 of the head unit 60 is moved vertically by the drive of the motor 2 and then a cylinder for the first nozzle 24 shown in FIG. 1 drives and lowers its piston to its lowest position so that the vertical movement of the table is transmitted to the first nozzle 24 and the position of the first nozzle 24 is adjusted in a direction A or in a direction B in FIG. 2A. Then the shape of the component 56 sucked and held by the first nozzle 24 remaining in the adjusted position is recognized. Reference numeral 96 in FIG. 2A denotes sliders for guiding the movement of the head unit 60 in the direction of the

arrow N in which the head unit moves (transverse direction). With forward or reverse rotation drive of the head unit driving motor 95, the frame 1 screwed with a rotating screw shaft of the head unit driving motor 95 can be rectilinearly reciprocated in the direction of the arrow N while guided by the sliders 96.

In the recognition of the component 57 sucked and held by the second nozzle 25 in FIG. 2B, upon the termination of the shape recognition of the component 56, raising the table 3 of the head unit 60 in the direction B with the drive of the motor 2 moves the second nozzle 25 upward in the direction B so as to place the bottom surface of the component 57 into the recognizable range L, because the bottom surface of the component 57 is lower than that of the component 56. This raising operation is performed prior to the shape recognition of the component 57, and the bottom surface of the component 57 is in the recognizable range L of the recognition camera 61 at the commencement of the shape recognition of the component 57, so that the shape recognition of the component 57 can be performed appropriately.

In the recognition of the component 58 sucked and held by the third nozzle 26 in FIG. 2C, upon the termination of the shape recognition of the component 57, lowering the table 3 of the head unit 60 in the direction A

with the drive of the motor 2 moves the third nozzle 26 downward in the direction A so as to place the bottom surface of the component 58 into the recognizable range L, because the bottom surface of the component 58 is higher than that of the component 57. This lowering operation is performed prior to the shape recognition of the component 58, and the bottom surface of the component 58 is in the recognizable range L of the recognition camera 61 at the commencement of the shape recognition of the component 58, so that the shape recognition of the component 58 can be performed appropriately.

In the recognition of the component 59 sucked and held by the fourth nozzle 27 in FIG. 2D, upon the termination of the shape recognition of the component 58, raising the table 3 of the head unit 60 in the direction B with the drive of the motor 2 moves the fourth nozzle 27 upward in the direction B so as to place the bottom surface of the component 59 into the recognizable range L, because the bottom surface of the component 59 is lower than that of the component 58. This raising operation is performed prior to the shape recognition of the component 59, and the bottom surface of the component 59 is in the recognizable range L of the recognition camera 61 at the commencement of the shape recognition of the component 59, so that the shape recognition of the component 59 can be performed

appropriately.

After that, the bottom surfaces of components sucked and held by other nozzles not shown in FIGS. 2A, 2B, 2C, and 2D are constantly adjusted and placed into the recognizable range L in the same way for the component recognition, by vertical movement of the table 3 of the head unit 60 in the direction A or in the direction B according to the height of the concerned component between the termination of the shape recognition of a component preceding the concerned component and the commencement of the shape recognition of the concerned component, so that the shapes of the components can be recognized continuously.

Upon the accomplishment of the imaging, the image processing unit 96 performs recognition processing on the basis of image data on electronic components imaged by the recognition camera 61. After that, postures of the components sucked and held by the nozzles are corrected on the basis of the result of the recognition processing and then the components are installed (mounted) in predetermined positions on an object to be installed such as a board.

In the correction of the postures of the components, the frame 1 is provided with a θ-direction driving motor 215 for correction in rotational direction about nozzle shafts, i.e., in a direction θ, and forward or

reverse rotation of a gear wheel 215a on a rotational shaft of the θ-direction driving motor 215 causes advance or retreat movement in transverse direction of a rack 216 meshing with the gear wheel 215a and thereby causes forward or reverse rotations of gear wheels 217 fixed to the nozzles, so that all the nozzles can be rotated forward or reversely in unison in the direction θ.

A working example of the first embodiment is such an electronic component mounting apparatus as shown in FIG. 1 which vertically moves ten nozzles to perform continuous shape recognition of a maximum of ten electronic components having different heights and mounts on a board a maximum of ten electronic components recognized and having different heights. Components of which shapes are recognized have heights, e.g., ranging from about one to a maximum of twenty five millimeters and, accordingly, vertical positions of the ten nozzles 24 to 33 are respectively controlled by the one motor 2 and by the ten selective cylinders 4 to 13. The width of the recognizable range L in the direction of the heights is, for example, 0.5 mm and therefore a mechanism that controls the positions with a resolution of 0.01 mm or higher can be realized.

In accordance with the first embodiment, shapes, heights, and the like of the components 56 to 59 of which surfaces to be recognized have different heights can be

continuously recognized by moving the nozzles 24 to 33 of the head unit 60 vertically in general under the control of the main controller 101 during the component shape recognition in the component mounting apparatus, according to the heights of the surfaces to be recognized of the components to be recognized 56 to 59. This arrangement eliminates the repetition of a component recognizing operation in which, for example, only components having surfaces to be recognized of similar heights are held and recognized and, with this arrangement, components having surfaces to be recognized of different heights can be held at the same time and component recognizing operations can be performed continuously, regardless of the heights of the surfaces to be recognized, so that an improvement in component mounting tact time (mounting process time) can be achieved. That is, even though the surfaces to be recognized of the components 56 to 59 held by a plurality of nozzles 24 to 33 cannot be accommodated all at once in the recognizable range L of the recognition camera 61, the components having the surfaces to be recognized of different heights can be held at the same time and component recognizing operations can be performed continuously, by moving each of the nozzles 24 to 33 of the head unit 60 vertically so that each of the surfaces to be recognized of the components 56 to 59 comes into the

recognizable range L.

Besides, the adjustment of heights of components is achieved by the motor 2, i.e., a single drive unit, though such adjustment conventionally has required drive units of which the number corresponds to the number of nozzles, and thus the cost and the weight of the apparatus can be reduced.

A surface of a component to be recognized by the recognition camera 61 is not confined to a bottom surface of the component. Examples of such a surface are as follows. In a component having protruding electrodes shaped like balls on its bottom surface, such as BGA (Ball Grid Array) and CSP (Chip Size Package) shown in FIGS. 8A and 8B, its surface to be recognized is not the bottom surface of a main body of the component but the balls themselves, and therefore it is necessary to detect the heights (in the case of three-dimensional recognition camera) or shapes (in the case of two-dimensional recognition camera) of the balls. In a component having leads extending from a main body thereof, such as QFP (Quad Flat Package) shown in FIGS. 8C, 8D, and 8E, its surface to be recognized is not the bottom surface of the main body of the component but the vicinity of tips of the leads, and therefore it is necessary to detect the heights (in the case of three-dimensional recognition camera) or shapes (in

the case of two-dimensional recognition camera) of the leads. In such a chip component as shown in FIGS. 8F and 8G, its surface to be recognized is the bottom surface of a main body of the component, and therefore it is necessary to detect the height (in the case of three-dimensional recognition camera) or shape (in the case of two-dimensional recognition camera) of the bottom surface of the main body of the component. In this manner, surfaces to be recognized of components to be recognized, e.g., the ball portion, the lead portion, and the bottom surface of the components may be situated in thoroughly different positions, even though surfaces of the components which are to be sucked by the nozzles, i.e., top surfaces of the components are situated at the same height. In accordance with the first embodiment, surfaces to be recognized of which the heights exhibit a variation can be recognized thoroughly in one operation of recognition.

Second Embodiment:

Hereinbelow, a second embodiment of the present invention will be described with reference to the drawings.

In the recognition of the height of a surface to be recognized of a component in the first embodiment, the height of the surface to be recognized of the component is required to be altered by a vertical movement in the event that the height of the surface to be recognized of the

sucked component differs from that of the formerly recognized component, and positioning control apparatus and method according to the second embodiment of the present invention are capable of detecting accurately start timing of driving the vertical movement, i.e., positioning timing. That is, the positioning control apparatus and method are such that an actuator such as a servo motor corresponding to the motor 2 of the drive unit is driven to control the position of a load by a ball screw or the like serving as a rotating shaft of the motor 2 and a velocity curve is produced for the positioning control with parameters, for example, of a target position, i.e., a height position where a surface to be recognized of a component is to be positioned by vertical movement of the surface, a maximum velocity in the movement up to the target position, and a maximum acceleration in the movement up to the target position. The positioning control apparatus and method are suitable for the component recognizing apparatus and method and the component mounting apparatus and method according to the first embodiment.

In other words, the positioning control apparatus and method according to the second embodiment are inexpensive and are capable of reducing a delay in the detection of start timing of positioning operation and starting the vertical movement with arbitrary timing, by

providing parameters of a positioning operation starting position and the specification of a shaft to be positioned and starting a positioning operation automatically upon the arrival at the positioning operation starting position of the shaft specified by the provided shaft specification.

Herein, the term "operation starting position" refers to a position in which timing is provided for starting a vertical positioning operation to bring to within a recognizable range a surface to be recognized that is moving in transverse direction, i.e., in N-direction in FIGS. 2A, 2B, 2C, and 2D, that is to say, a vertical drive starting position. When the component 56 on the first nozzle 24 reaches a position in N-direction where the recognition is completed, for example, in the transverse movement in N-direction, a vertical positioning operation for the second nozzle 25 is started to make a movement to a vertical position where the component 57 on the second nozzle 25 can be recognized. The term "shaft specification" refers to specifying an actuator in N-direction. The term "to provide parameter" refers to notifying a shaft specification from the main controller 101 to a positioning controller 102.

In the operation in vertical direction, the positioning control apparatus according to the second embodiment of the present invention produces during the

vertical movement a velocity curve in the vertical movement of the selected component holding member with parameters of a target position in the direction of height at the time when the vertical movement of the selected component holding member is controlled by means of the drive unit so as to position a surface to be recognized of the component within a recognizable range of the recognition unit, a maximum velocity in the vertical movement of the selected component holding member up to the target position, and a maximum acceleration in the vertical movement of the selected component holding member up to the target position, and automatically starts the positioning operation of the selected component holding member driven by the drive unit on the basis of the velocity curve in response to a positioning operation starting instruction upon the arrival at the positioning operation starting position of the selected component holding member moving transversely toward the recognition unit, so that the vertical operation can be started at arbitrary timing without delay in detection. Herein, the term "target position" refers to a terminal position of the vertical movement, for example, a position in the direction of height in which the component 57 on the second nozzle 25 can be recognized, in the ascent from the position for the first nozzle 24 to the position for the second nozzle 25. A positioning control apparatus

according to a first aspect of the present invention is provided with parameters of a positioning operation starting position and a shaft specification and automatically starts a positioning operation in response to a positioning operation starting instruction and upon the arrival at the positioning operation starting position of a shaft specified by the provided shaft specification.

This arrangement ensures a positioning in which arbitrary positioning operation starting timing is provided accurately and in an inexpensive manner.

A positioning control apparatus according to a second aspect of the present invention is provided with parameters of a plurality of target positions and a plurality of positioning operation starting positions of the first aspect and automatically starts a positioning operation in response to a positioning operation starting instruction and upon the arrival at the positioning operation starting positions of a shaft specified by the provided shaft specification and executes a plurality of positioning operations.

This arrangement ensures positioning in which arbitrary positioning operation starting timing is provided a plurality of times accurately and in an inexpensive manner, and ensures continuous positioning.

A positioning control apparatus according to a

third aspect of the present invention has the second aspect provided with parameters of a plurality of positioning operation ending positions and detects the normal accomplishment of individual positioning operations in continuous operation.

This arrangement ensures the detection of the normal accomplishment of individual positioning operations in continuous positioning operation and ensures an instantaneous suspension upon the occurrence of an abnormal condition.

In a positioning control apparatus according to a fourth aspect of the present invention, an electronic component mounting apparatus is provided with the positioning control apparatus of the first aspect.

In a positioning control apparatus according to a fifth aspect of the present invention, an electronic component mounting apparatus is provided with the positioning control apparatus of the second aspect.

In a positioning control apparatus according to a sixth aspect of the present invention, an electronic component mounting apparatus is provided with the positioning control apparatus of the third aspect.

FIG. 9 is a block diagram illustrating a positioning control configuration that can be applied to the component mounting apparatus according to the second

embodiment of the present invention. As shown in FIG. 9, this positioning control configuration has a main controller 101 for outputting instructions of a target position (Pt) of a load, a maximum velocity (Vmax) in a movement up to the target position, a maximum acceleration (αmax) in a movement up to the target position, a positioning operation starting position (Pa), a shaft specification (A), and a positioning operation starting instruction (C); a positioning controller 102 that calculates a velocity curve on the basis of the provided instructions to output an instructive velocity and functions as an example of a first control unit; servo drivers 103 and 106 that drive and control servo motors on the basis of the provided instructions and function as an example of a second control unit (for example, a transverse movement servo driver 103 (subjected to a positioning control in transverse movement) and a vertical drive servo driver 106 both for a plurality of suction nozzles (suction nozzles 211 in FIG. 17 that will be mentioned below and suction nozzles 24 to 33 in FIG. 18 that will be mentioned below) as an example of a plurality of component holding members); servo motors 104 and 107 attached to mechanical devices (e.g., a transverse movement servo motor 104 and a vertical drive servo motor 107 for a plurality of suction nozzles (corresponding to, for example, the head unit

driving motor 95 and the vertical drive motor 2 of the first embodiment, a transverse movement servo motor and a vertical drive actuator 212 in FIG. 17 that will be mentioned below, and a transverse movement servo motor and a vertical drive motor 2 in FIG. 18 that will be mentioned below)); and mechanical devices 105 and 108 to be finally positioned.

This configuration will be specifically described in correspondence to the first embodiment as follows. For the main controller 101, a target position (Pt)of a load in a vertical movement device for the nozzles (a device composed of the motor 2, the table 3, the first to tenth cylinders 4 to 13, and others) is a target position at the time when the vertical movement of the selected component holding member such as a nozzle is controlled by means of the drive unit so as to position a surface to be recognized of the component within a recognizable range of the recognition unit, and a target position (Pt) of a load in a transverse movement device for the nozzles, i.e., a transverse movement device for the head (a device composed of the transverse movement motor and others) is a vertical drive starting position for the recognition of a surface to be recognized of the component within a recognizable range of the recognition unit, that is, a vertical drive starting position for the selected nozzle. A maximum velocity (Vmax)

in a movement up to the target position is a maximum velocity in the vertical movement or the transverse movement of the selected nozzle up to the target position. A maximum acceleration (αmax) in a movement up to the target position is a maximum acceleration in the vertical movement or the transverse movement of the selected nozzle up to the target position. The positioning operation starting position (Pa) is a starting position of a positioning operation in the direction of height and in the transverse direction of the selected nozzle driven by the motor 2 and the transverse movement motor. The shaft specification (A) is the selection of the selected nozzle. The positioning operation starting instruction (C) is a starting instruction of a positioning operation in the direction of height and in the transverse direction of the selected nozzle driven by the motor 2 and the transverse movement motor.

The above-mentioned term "load" refers to an actuator and its mechanical device that move the frame 1, which is a base of the table 3, as a load in the transverse direction, i.e., in horizontal direction (in the N-direction). That is, the load in the device for the transverse movement, i.e., the movement in the right-and-left direction is the frame 1, and the load in the device for the vertical movement is the table 3. The positioning

controller 102 calculates velocity curves in both the vertical movement and the transverse movement of the selected nozzle on the basis of the instructions provided by the main controller 101 and outputs velocity instructions based on the calculated velocity curves. The servo drivers 103 and 106 drive and control the servo motors on the basis of the velocity instructions provided by the positioning controller 102 and correspond to the transverse movement servo driver 103 and the vertical drive servo driver 106 for a plurality of suction nozzles 24 to 33 as an example of a plurality of component holding members. The servo motors 104 and 107 attached to the mechanical devices correspond to the transverse movement servo motor and the vertical drive motor 2 for a plurality of suction nozzles. The mechanical devices 105 and 108 to be finally positioned correspond to the transverse movement device for transverse movement and the vertical movement device for the suction nozzles.

Operations of the calculation of the velocity curves and of the output of the instructive velocity that are executed by the positioning controller 102 will be described below with reference to FIGS. 10 and 11.

The main controller 101 initially outputs for the transverse movement driver 103 instructions of a target position for the transverse movement, a maximum velocity

(V103max), and a maximum acceleration (α103max) without providing instructions of a positioning operation starting position and a shaft specification (the selection of a nozzle) for the driver 103, outputs for the vertical driver 106 instructions of a positioning operation starting position and a shaft specification and instructions of a target position for the vertical drive, a maximum velocity (V106max), and a maximum acceleration (α106max), and outputs a positioning operation starting instruction. The positioning controller 102 is then switched from a status (a step #1 in FIG. 11) in which the controller 102 is waiting for a positioning operation starting instruction to the following step #2, and determines whether there is a shaft specification or not (the step #2 in FIG. 11).

In the next place, the transverse movement driver 103 has no shaft specification and therefore goes from the step #2 in FIG. 11 to a step #3 in FIG. 11, and velocity instruction setting the maximum velocity (V103max) and the maximum acceleration (α103max) is outputted for the transverse movement driver 103 (the step #3 in FIG. 11). On the basis of the velocity instruction setting the maximum velocity (V103max) and the maximum acceleration (α103max), the transverse movement driver 103 drives and controls the transverse movement servo motor to control the transverse movement of each nozzle up to the target position that is a

specified vertical drive starting position, and holds the posture of each nozzle that can be recognized by the recognition camera 61.

In the next place, the vertical driver 106 has a shaft specification that specifies a nozzle to be selected for selecting a nozzle to be vertically driven from among a plurality of nozzles and therefore goes from the step #2 in FIG. 11 to a step #4 in FIG. 11, and waits for the specified shaft, i.e., the selected nozzle to reach the positioning operation starting position (the step #4 in FIG. 11). Whether the nozzle has reached the positioning operation starting position or not can be detected by the positioning controller 102. That is, the positioning controller 102 controls the servo driver 103 for the positioning in the transverse movement in the N-direction, and therefore, the position in the N-direction and the positioning operation starting position can be detected by the positioning controller 102.

When the selected nozzle then reaches the positioning operation starting position, velocity instruction setting the maximum velocity (V106max) and the maximum acceleration (α106max) is outputted for the vertical driver 106 (the step #5 in FIG. 11). Then, on the basis of the velocity instruction setting the maximum velocity (V106max) and the maximum acceleration (α106max), the

vertical driver 106 drives and controls the vertical drive servo motor 2 to control the vertical movement of each nozzle to a specified height as the target position so that the surface to be recognized of the component sucked by the concerned nozzle comes into the recognizable range L of the recognition camera 61.

After that, the positioning controller 102 is brought into the status (the step #1 in FIG. 11) in which the following positioning operation starting instruction is waited for. That is, an instruction of the vertical movement or the transverse movement for a nozzle selected in the next place is waited for in the status.

With this configuration, the positioning operation of each selected nozzle can be started accurately and in an inexpensive manner with arbitrary timing.

In accordance with the second embodiment, the positioning operation for the selected component holding member driven by the drive unit on the basis of the velocity curve is started automatically with a positioning operation starting instruction, upon the arrival at a positioning operation starting position of the selected component holding member that has been moving transversely toward the recognition unit, and therefore, the positioning operation can be started accurately and in an inexpensive manner with arbitrary timing.

The present invention is not limited to the above embodiments but may be implemented in other various forms.

For example, a plurality of parameters of target positions and positioning operation starting positions may be provided for executing processes shown in FIG. 12. That is, a positioning operation may be started from one positioning operation starting position in a step #6, whether the positioning operation has been completed or not may be thereafter detected, and an advance to a step #7 may be made only if the positioning operation has been completed. If there is the next target position, a return to a step #4 may be made and a positioning operation may be started from the next positioning operation starting position. If there is not the next target position in the step #7, a return to a step #1 may be made. With this arrangement, as shown in FIG. 14, continuous positioning operations can be executed accurately and in an inexpensive manner with arbitrary timing.

On the other hand, a plurality of positioning operation ending positions may be added for executing processes shown in FIG. 13. That is, a positioning operation is started from a positioning operation starting position in a step #6, whether the positioning operation has been completed or not is thereafter detected. If the positioning operation has not been completed, whether a

positioning operation ending position has been reached or not is detected in a step #8. If the positioning operation ending position has not been reached, a return to the step #6 is made. If the positioning operation has not been completed and the positioning operation ending position has been reached in the step #8, the detection of abnormality is notified in a step #9. An advance to a step #7 may be made only if the positioning operation ending position has been reached in the step #6. If there is the next target position, a return to a step #4 may be made. If there is not the next target position, a return to a step #1 may be made. With this arrangement, the fact that each positioning operation in continuous positioning operations has normally been done can be detected. In this process, whether the positioning operation has been completed or not is judged (detected) according to the termination of output of the instructive velocity or with an encoder (position detector) installed in the servo motor 104. Whether the positioning operation ending position has been reached or not is judged by controlling the vertical movement servo driver 106 in accordance with the position in N-direction. In other words, an ascent to a position for the recognition of the second nozzle 25 is made in a position in N-direction (for example, a recognition ending position for the first nozzle 24), and whether the ascent has been completed before another

position (e.g., a recognition starting position for the second nozzle 25) is judged. If the ascent has not been completed, abnormality is detected (as a situation in which recognition is impossible).

With such a positioning control apparatus provided for or applied to the electronic component mounting apparatus such as the first embodiment that requires positioning at high speed with high accuracy, positioning operations can be started accurately and in an inexpensive manner with arbitrary timing; however, it is needless to say that the application is not limited to the above.

The second embodiment can be applied not only to component mounting apparatus and method but to positioning control apparatus and method for driving a plurality of actuators such as servo motors and controlling positions of loads by ball screw or the like, so that positioning operations can be started accurately and in an inexpensive manner with arbitrary timing. That is, apparatus for driving a plurality of actuators such as servo motors and controlling positions of loads by ball screw or the like can be configured so that the apparatus has the functions of producing a velocity curve with component recognizing apparatus parameters of a target position, a maximum velocity in the movement up to the target position, and a maximum acceleration in the movement up to the target

position and starting a positioning operation in response to a positioning operation starting instruction, parameters of a positioning operation starting position and a shaft specification are provided, a positioning operation is automatically started upon the provision of a positioning operation starting instruction and upon the arrival at the positioning operation starting position of a shaft specified by the provided shaft specification, and the positioning is thereby executed with arbitrary timing.

That is to say, in the case that timing for starting the positioning of one load must be provided according to the position of the other load and the timing for starting the positioning must be changed in the positioning control for driving actuators such as servo motors and controlling the positions of loads by ball screw or the like, the positioning operation of the other load is automatically started upon the arrival of the position of one load at a positioning operation starting position and a delay in detection is thereby reduced and the positioning operation can be started in an inexpensive manner with arbitrary timing. In the case that timing for starting the positioning of one load must be provided according to the position of the other load, for example, when the operations of vertical movement and movement in transverse direction, i.e., in right-and-left direction are made by means of the

servo drivers 103 and 106, the motors 104 and 107, and the mechanical devices 105 and 108, the position in right-and-left direction changes with the sizes of components in the direction of height of the components and in the direction of the movement to above the recognition device. The timing for starting the vertical movement accordingly changes and, therefore, the timing for starting the positioning of the other load, e.g., in vertical direction must be provided according to the position of one load, e.g., in right-and-left direction in some cases.

As a result, a delay in detection can be reduced and a positioning control by which positioning operations are started in an inexpensive manner with arbitrary timing can be executed, by providing parameters of a positioning operation starting position and a shaft specification and starting automatically a positioning operation upon the arrival at the positioning operation starting position of a shaft specified by the provided shaft specification.

In such a configuration, a plurality of parameters of target positions and positioning operation starting positions may be provided so that continuous positioning operations can be executed accurately and in an inexpensive manner with arbitrary timing.

In such a configuration, furthermore, a plurality of positioning operation ending positions may be added so

that the normal completion of each positioning operation in continuous positioning operations can be detected.

In accordance with the second embodiment, the following issues can be resolved.

Conventionally, such a positioning control arrangement for a load, as shown in FIG. 15, is provided with a main controller 201 for outputting a target position (Pt) of a load, a maximum velocity (Vmax) up to the target position, a maximum acceleration (αmax) up to the target position, and a positioning operation starting instruction (C), a positioning controller 202 that outputs an instructive velocity on the basis of the provided instructions, a servo driver 203 that drives and controls a servo motor on the basis of the provided instructive velocity, a servo motor 204 attached to a mechanical device, and a mechanical device 205 to be finally positioned, and the positioning controller 202 is configured so as to output an instructive velocity on the basis of the provided instructions, as shown in FIG. 16.

As shown in FIG. 17, an electronic component mounting apparatus equipped with such a positioning apparatus for a load includes a plurality of component suction nozzles 211, ... , 211 that suck and hold electronic components at component feeding units such as component feeding cassettes and install the components on

installation positions on boards, and the plurality of component suction nozzles 211, ..., 211 is provided with actuators 212, ..., 212 such as servo motors serving as vertical movement devices and a transverse movement device having a transverse movement servo motor A.

In recent years, particularly, mounting at high speed with high accuracy has been demanded, and there have been provided devices which recognize a plurality of components and install the components at a high speed by recognizing with a recognition unit 211 the shape and suction posture of a component 220 sucked and held by a nozzle while moving the nozzle or the like in the direction of an arrow, as shown in FIGS. 19A and 19B.

In the recognition of the height of a surface to be recognized of a component, however, the height of the surface to be recognized of the component that is moving is altered by a vertical movement device each time the height of the surface to be recognized of the sucked component differs from that of the formerly recognized component. This operation requires means for detecting the positioning timing of the vertical movement device, and a variation in the timing for each component makes the means complicated and expensive and impedes a speed-up by a delay in the detection.

According to the second embodiment, by contrast,

means for detecting the positioning timing of the vertical movement device is not required. Besides, positioning can be executed with arbitrary timing by producing a velocity curve with component recognizing apparatus parameters of a target position, a maximum velocity in the movement up to the target position, and a maximum acceleration in the movement up to the target position, providing the function of starting the positioning operation in response to a positioning operation starting instruction, providing parameters of a positioning operation starting position and a shaft specification, and starting the positioning operation automatically upon the provision of a positioning operation starting instruction and upon the arrival at the positioning operation starting position of a shaft specified by the provided shaft specification, and therefore, positioning operations can be started accurately and in an inexpensive manner with arbitrary timing.

In the recognition of the height of a surface to be recognized of a component particularly in a component mounting apparatus which has an increased number of nozzles for the purpose of achieving a speed-up as described in regard to the first embodiment and as shown in the FIG. 18 and which is equipped with actuators 14 to 33 for making vertical movement operation collectively and an actuator for making transverse movement operation, e.g., a servo motor

for transverse movement in an XY robot unit for driving a head unit, means for detecting the positioning timing of a vertical movement device is not required and positioning operations can be preferably started accurately and in an inexpensive manner with arbitrary timing, when the height of a surface to be recognized of a component that is moving is altered by the vertical movement device each time the height of the surface to be recognized of the sucked component differs from that of the formerly recognized component.

Third Embodiment:

Hereinbelow, component recognizing method and apparatus and component mounting method and apparatus according to a third embodiment of the present invention will be described with reference to the drawings.

Prior to the description of the third embodiment, an object of the embodiment will be described.

In recent years, high productivity in electronic component mounting apparatus for mounting electronic components on circuit boards has been demanded with the miniaturization and an increase in the variety of electronic components and with an increase in the count of electronic components to be mounted. In particular, a further speed-up in the recognition of electronic components and in the position correction of electronic components has been demanded.

There have been known electronic component mounting apparatus having a component feeding unit for feeding electronic components, a head unit equipped with nozzles for sucking and holding electronic components, a drive device for moving the head unit to a specified position, a component mounting area having circuit boards on which electronic components are to be mounted, and a recognition area equipped with a line sensor for imaging the holding status of electronic components.

In such an electronic component mounting apparatus, a component recognition process is configured as shown in FIG. 22. In FIG. 22, reference numeral 401 denotes electronic components, numeral 403 denotes a head unit equipped with a plurality of nozzles 402 (four nozzles in FIG. 22), numeral 412 denotes an X-Y drive device for moving the head unit 403 in X-Y directions, numeral 413 denotes a vertical drive device for moving the nozzles 402 vertically, numeral 404 denotes a drive control unit for controlling the X-Y drive device 412 and the vertical drive device 413, numeral 405 denotes a line sensor for imaging the holding status of the electronic components 401, numeral 406 denotes an image processing unit that performs recognition processing while controlling the line sensor 405, and numeral 407 denotes a main control unit that occasionally controls the image processing unit 406 and the drive control unit

unit 404 and calculates a correction quantity for a positional offset of an electronic component 401 with respect to a nozzle suction position on the basis of a recognition processing result obtained from the image processing unit 406.

When the electronic components 401 are imaged by the line sensor 405, a height (a distance) from the line sensor 405 to the bottom surface of an electronic component 401 is preferably set so as to coincide with the focus of the line sensor 405. Therefore, heights of the nozzles 403 are required to be set so as to be changed in accordance with shapes of the electronic components 401, particularly in accordance with thicknesses of the components 401. Herein, the height (distance) is defined as component holding height, and a component holding height that makes a component to be imaged come into the focus of the line sensor 405 is defined as focus coincident height. A component holding height can be changed by vertical movement of the nozzles 402 with use of the vertical drive device 413.

Operations of a component recognizing method according to a prior art in such a configuration will be described.

Four electronic components 401 are sucked and held by the head unit 403 equipped with four nozzles 402 and the head unit 403 is moved to a start position in the

recognition area equipped with the line sensor 405. On the basis of the control by means of the main control unit 407, the drive control unit 404 moves the head unit 403 at constant velocity in the X-direction over the line sensor 405 and the holding status of each of the four electronic components 401 is imaged, with component holding heights of the nozzles 402 set at a focus coincident height fit for four electronic components 401. When the imaging of all the electronic components 401 is completed, the image processing unit 406 performs recognition processing on the basis of image data of the imaged electronic components 401. After that, the main control unit 407 calculates correction quantities with respect to mounting positions in a circuit board on the basis of the recognition processing result obtained from the image processing unit 406 and each electronic component 401 is installed on the circuit board.

For imaging the holding status of a plurality of electronic components 401 at one time in a series of component recognition processes, however, the use of the above-mentioned method has to be limited to electronic components 401 which have similar thicknesses when sucked and held by the head unit 403. When the imaging is performed in a state in which electronic components having greatly different thicknesses exist in a plurality of electronic components 401 sucked and held by the head unit

403, the focus of the line sensor 405 is situated at a fixed height. On the other hand, component holding heights of the nozzles 403 exhibit a variation according to the electronic components sucked and held and having different thicknesses and therefore some of the electronic components to be imaged are out of the focus of the line sensor 405 and the holding status cannot be imaged accurately.

For this reason, each group of electronic components having similar thicknesses must be separately subjected to all the processes in component suction holding, component recognition, and component installation, and there arises an issue in the productivity of component mounting because of an extra time for the movement of the head unit 403 and the occurrence of empty nozzles which are sucking no components.

In view of the above-mentioned issue, it is an object of the third embodiment to permit a series of component recognition operations to be made at one time and accurately with electronic components having different thicknesses sucked and held by the head unit and, consequently, to increase the productivity of component mounting by reducing the extra time for the movement of the head unit and minimizing the occurrence of empty nozzles.

Hereinbelow, the third embodiment of the present invention will be described in detail with reference to FIG.

20.

In FIG. 20, reference numerals 301 and 310 denote electronic components, numeral 303 denotes a head unit equipped with a plurality of suction nozzles 302 (four nozzles in FIG. 20) as an example of component holding members, numeral 312 denotes an X-Y drive device (corresponding to the X-Y robot 500X in the first embodiment) for moving the head unit 303 in X-Y directions, numeral 313 denotes a vertical drive device for moving the nozzles 302 vertically, numeral 304 denotes a drive control unit for controlling the X-Y drive device 312 and the vertical drive device 313, numeral 305 denotes a line sensor as an example of a recognition unit for imaging the holding status of the electronic components 301 and the electronic component 310, numeral 306 denotes an image processing unit that performs recognition processing while controlling the line sensor 305, and numeral 307 denotes a main control unit that occasionally controls the image processing unit 306, the drive control unit 304, and various drive devices or members and calculates correction quantities for positional offsets of the electronic components 301 and the electronic component 310 with respect to nozzle suction positions on the basis of a recognition processing result obtained from the image processing unit 306. The main control unit 307 also controls various mounting operations such as feeding,

suction, recognition, and installation of components in the whole component mounting apparatus.

There is a difference in thickness, i.e., height in the vertical direction in FIG. 20, between the electronic components 301 and the electronic component 310. In the imaging over the line sensor 305, accordingly, settings of component holding heights of the nozzles 302 differ between the electronic components 301 and the electronic component 310 which are sucked by the nozzles 302. This means that surfaces to be recognized, e.g., bottom surfaces of the plurality of electronic components 301 and 310 have such a variation in height that not all the surfaces are within a recognizable range (L) of the line sensor 305, for example, when bottom end surfaces of the plurality of nozzles 302 are situated at the same height. Herein, a component holding height of a nozzle 302 which is fit for the imaging of the surfaces to be recognized, e.g., the bottom surfaces of the electronic components 301 is defined as first focus coincident height. A component holding height of a nozzle 302 which is fit for the imaging of the surface to be recognized, e.g., the bottom surface of the electronic component 310 is defined as second focus coincident height.

The component holding heights of the nozzles 302 are made variable according to sucked and held electronic components with different thicknesses, for the purpose of

correcting to a focus coincident height the component holding heights of nozzles 302 having sucked and having held electronic components of which the bottom surfaces as an example of surfaces to be recognized do not coincide with the focus of the line sensor 305, that is, reside nearer or farther than the focal position of the line sensor 305, according to the thicknesses of the electronic components, in contrast to the focus of the line sensor 305 situated at a fixed height. In such an apparatus in which component holding heights are variable, the heights can be changed by vertical movement of the nozzles 302 by means of the vertical drive device 313. The details of the vertical movement of the nozzles 302 and the vertical drive device 313 which are provided for the head unit 303 will be described later.

A direction shown by reference character X1 in FIG. 20 is a direction in which the head unit 303 moves at constant velocity with the nozzles 302 set at the first focus coincident height fit for the scanning and imaging of the electronic components 301 and which is orthogonal to a longitudinal direction of the line sensor 305. A direction shown by reference character X2 in FIG. 20 is a direction in which the head unit 303 moves at constant velocity with the nozzles 302 set at the second focus coincident height fit for the scanning and imaging of the electronic component 310

and which is a reverse direction opposite to the traveling direction X1 assumed as a forward direction of the head unit 303 (Both the directions X1 and X2 are included in X-direction.).

A configuration and operations concerning the vertical movement of a plurality of nozzles 302 provided for the head unit 303 will be described below with reference to FIG. 23. FIG. 26 illustrates relations between the control unit and the drive device and the like in the component mounting apparatus of the third embodiment.

As shown in FIG. 23, the head unit 303 is composed of ten nozzles 302, ten nozzle shafts 314, a vertical drive device 313, and a head unit board 315. The vertical drive device 313 has a vertical drive motor 316, a screw engagement section 317, an L-type plate 318 corresponding to the table 3 of the former embodiments, ten coil springs 319, ten nozzle selection valves 321, cylinder sections 320 that correspond to the cylinders 4 to 13 of the former embodiments and move vertically with ON/OFF operations of the nozzle selection valves 321, a nozzle turning timing belt 322, and gear sections 323. The numbers of the nozzles 302, the coil springs 319, and the nozzle selection valves 321 which are shown in FIG. 23 are ten, respectively; however, the numbers may be plural in general and therefore the members will be referred to as a plurality of nozzles

302, a plurality of coil springs 319, and a plurality of nozzle selection valves 321 in the following description. Reference numeral 89 in FIG. 26 denotes a nozzle suction device for controlling suction operations of the nozzles.

In the vertical movement of a plurality of nozzles 302 in such a configuration, the vertical drive motor 316 fixed to the head unit board 315 is used as a drive source, rotational driving force of the vertical drive motor 316 is transmitted to the screw engagement section 317 provided in the L-type plate 318, and the L-type plate 318 is moved vertically, i.e., upward or downward by a predetermined amount with forward or reverse rotation in the screw engagement section 317. A plurality of nozzle selection valves 321 are fixed to the L-type plate 318 and the valves are configured so as to move cylinder units 320 selectively and vertically. The vertical movement by means of the nozzle selection valves 321 cannot be driven with the adjustment of the amount of the vertical movement, as distinct from the vertical movement with the vertical drive motor 316 that is used as the drive source. That is because there are only two possible ways of the vertical movement, i.e., downward drive of a cylinder section 320 or a return to the original position of the cylinder section 320 with ON/OFF operation of a nozzle selection valve 321. A cylinder section 320, driven downward selectively by a

nozzle selection valve 321 in this way, pushes an upper end portion of a nozzle shaft 314 to move down a nozzle 302 connected to the nozzle shaft 314 and positions a tip of the nozzle 302 at a component holding height H1 shown in FIG. 23. In FIG. 23, one nozzle 302 out of a plurality of nozzles 302 has been pushed down selectively. In a state in which the nozzle 302 has been pushed down in this way, driving force of the vertical drive motor 316 is exerted upon the nozzle 302 through the medium of the nozzle selection valve 321 fixed to the L-type plate 318 and of the cylinder section 320, and therefore an amount of the vertical movement of the nozzle 302 can be varied by means of the vertical drive motor 316.

When the nozzle selection valve 321 is in OFF state, the nozzle 302 is being pushed upward by a biasing force of a coil spring 319, because one end of the coil spring 319 is engaged with the nozzle shaft 314 serving as an axis of the coil spring 319. The tip of the nozzle 302 is therefore situated at a basic height H0 shown in FIG. 23. The gear sections 323 of the nozzle shafts 314 mesh with the nozzle turning timing belt 322 and the head unit board 315 corresponding to the frame 1 is provided with such a θ-direction driving motor 215 as shown in FIG. 1 for the first embodiment. Forward and reverse rotation of a gear 215a on a rotating shaft of the θ-direction driving motor

215 causes movement of the nozzle turning timing belt 322 meshing with the gear 215a and forward and reverse rotation or unidirectional rotation of the gear sections 323 of the nozzle shafts 314, so that a turning angle of the nozzle shafts 314 can be adjusted.

Operations of the component recognizing method according to the third embodiment in the above-mentioned configuration will be described with reference to FIG. 27.

Three electronic components 301 and one electronic component 310 are sucked and held by the head unit 303 equipped with four nozzles 302 (see a step 21 of FIG. 27) and the head unit 303 is moved to a start position in a recognition area equipped with the line sensor 305. On the basis of the control by means of the main control unit 307, the drive control unit 304 moves the head unit 303 at constant velocity in the direction X1 over the line sensor 305 with the heights of the nozzles 302 set at the first focus coincident height fit for the electronic components 301 and the holding status of the electronic components 301 and the electronic component 310 is imaged. To be more specific, for example, the main control unit 307 acquires information on a group of nozzles with components that can be recognized at the first focus coincident height among the components sucked and held by the nozzles and information on a group of nozzles with components that can be recognized at

the second focus coincident height different from the first (see a step 22 of FIG. 27), and the heights of all the nozzles 302 are set at the first focus coincident height on condition that the components that can be recognized at the first focus coincident height are initially recognized (see a step 23 of FIG. 27). With the heights of all the nozzles 302 set at the first focus coincident height in this manner, the head unit 303 is moved at constant velocity in the direction X1 over the line sensor 305 and the holding status of the electronic components 301 and the electronic component 310 is imaged (see a step 24 of FIG. 27).

When these imaging operations are completed, the image processing unit 306 performs recognition processing on the basis of image data of the electronic components 301 and the electronic component 310 which have been imaged. At this time, the heights of the nozzles 302 have been set at the first focus coincident height fit for three electronic components 301, so that image data of recognition image imaged clearly is obtained from three electronic components 301; however, the height of the nozzle 302 holding the electronic component 310 of which the thickness is different from the thickness of the electronic components 301 has not been set at the second focus coincident height but has been set at the first focus coincident height, so that image data of recognition image imaged unclearly is obtained from the

electronic component 310.

The drive control unit 304 subsequently switches the traveling direction to the direction X2 so as to reciprocate the head unit 303 and moves the head unit 303 at constant velocity in the direction X2 over the line sensor 305 with the heights of the nozzles 302 changed to and set at the second focus coincident height fit for the electronic component 310, and the holding status of the electronic components 1 and the electronic component 310 is imaged. To be more specific, for example, the main control unit 307 sets the heights of all the nozzles 302 at the second focus coincident height on the basis of the group information acquired before, on condition that the components that can be recognized at the second focus coincident height are subsequently recognized (see a step 25 of FIG. 27). With the heights of all the nozzles 302 set at the second focus coincident height in this manner, the head unit 303 is moved at constant velocity in the direction X2 over the line sensor 305 and the holding status of the electronic components 301 and the electronic component 310 is imaged (see a step 26 of FIG. 27).

When these imaging operations are completed, the image processing unit 306 performs recognition processing on the basis of image data of the electronic components 301 and the electronic component 310 which have been imaged. At

this time, the heights of the nozzles 302 have been set at the second focus coincident height fit for the electronic component 310, so that image data of recognition image imaged clearly is obtained from the electronic component 310; however, the heights of the nozzles 302 holding three electronic components 301 of which the thickness is different from that of the electronic component 310 have not been set at the first focus coincident height but have been set at the second focus coincident height, so that image data of recognition image imaged unclearly is obtained from three electronic components 301.

When the recognition of the holding status of the electronic components 301 and the electronic component 310 is completed, the main control unit 307 calculates correction quantities with respect to installation positions in a circuit board on the basis of the recognition processing result obtained from the image processing unit 306. At this time, the main control unit 307 selects out for three electronic components 301 the recognition processing result in which the nozzles 302 were imaged at the first focus coincident height fit for the electronic components 301, and selects out for one electronic component 310 the recognition processing result in which the nozzle 302 as imaged at the second focus coincident height fit for the electronic component 310. To be more specific, for

example, the main control unit 307 selects out image data of the electronic components 301 fit for the first focus coincident height from image data of recognition image obtained from the recognition at the first focus coincident height and selects out image data of the electronic component 310 fit for the second focus coincident height from image data of recognition image obtained from the recognition at the second focus coincident height, on the basis of the group information acquired before.

On the basis of the recognition processing result fit for each electronic component, correction quantities for positional offsets of the electronic components 301 and the electronic component 310 with respect to suction positions of the nozzles 302 are taken into account (see a step 27 of FIG. 27) and the electronic components are mounted on installation positions in the circuit board (see a step 28 of FIG. 27).

In the imaging with the line sensor 305 in the third embodiment, image data of both components fit for a focus coincident height and components not fit for the focus coincident height is temporarily captured and stored in a memory 90 for image processing, and thereafter, only the image data of the components fit for the focus coincident height is finally selected under the control of the main control unit 307; however, the embodiment is not limited to

this arrangement. For example, image data of only components fit for a focus coincident height may be captured in the imaging with the line sensor 305, with previous reference to thickness data of electronic components held by the nozzles 302 among data stored in the memory 91 for mounting in which such information is stored as component data including types, thicknesses, widths, lengths, weights, and the like of components for use in component mounting, mounting order in the suction of components and the like, types of nozzles installed in the head unit, and relations between types of nozzles and types of components (in other words, information showing which component is to be sucked by which nozzle).

According to the third embodiment, as described above, in the component recognizing method in the electronic component mounting apparatus having the head unit equipped with the plurality of nozzles each for sucking the electronic component, the X-Y drive device for moving the head unit to a specified position in X-Y directions, the vertical drive device for driving vertically the nozzles provided for the head unit, the drive control unit for controlling the X-Y drive device and the vertical drive device, the line sensor for imaging electronic components sucked by the nozzles, the image processing unit for performing recognition processing while controlling the line

sensor, and the main control unit for controlling the drive control unit and the image processing unit, the head unit is reciprocated in the X-direction over the line sensor, and the nozzles are vertically moved simultaneously so as to change heights of electronic components sucked by the nozzles to specified heights and the electronic components are imaged with the line sensor, each time the traveling direction of the head unit is switched over.

In accordance with the third embodiment, the electronic components having different thicknesses are respectively sucked and held by the plurality of nozzles provided for the head unit. When holding status of those components is imaged in a series of component recognition processes, the nozzles are simultaneously moved vertically, for example, so as to have a height (a focus coincident height) fit for the imaging of a group of electronic components of which thicknesses are within an identical range among all the sucked electronic components. The head unit is moved in a forward direction of the X-direction over the line sensor while scanning and imaging are executed. For the purpose of imaging accurately the remaining group of electronic components for which the height of the nozzles in the preceding imaging is unsuitable, the traveling direction of the head unit is subsequently switched to a reverse direction and the nozzles are simultaneously moved

vertically so as to have a height (a focus coincident height) fit for the imaging of the remaining group of electronic components. The head unit is then moved in the reverse direction over the line sensor while scanning and imaging are executed anew. As a result, after the completion of the imaging of all the electronic components, recognition results of the imaging at the respective focus coincident heights fit for the electronic components with different thicknesses are selected out, and thus holding status of a plurality of electronic components with different thicknesses can be imaged accurately in a series of component recognition processes.

Fourth Embodiment:

Hereinbelow, a fourth embodiment of the present invention will be described in detail with reference to FIG. 21.

A configuration that is required for component recognition processes in an electronic component mounting apparatus of the fourth embodiment is basically the same as that in the third embodiment as described with reference to FIG. 20 and FIG. 23. Differences of the configuration of the fourth embodiment from that of the third embodiment will be described with reference to FIG. 21.

As shown in FIG. 21, reference numeral 305 denotes a first line sensor for imaging the holding status of

electronic components 301 and an electronic component 310, and numeral 311 denotes a second line sensor. These are configured so that a head unit 303 moves in one direction in a straight line over the first line sensor 305 and the second line sensor 311 and moves in a direction orthogonal to respective longitudinal directions of the first line sensor 305 and the second line sensor 311 both of which are rectangularly shaped. The configuration is made so that the electronic components 301 and the electronic component 310 may not interfere with an imaging area of the second line sensor 311 in the imaging of the electronic components 301 and the electronic component 310 over the first line sensor 305. The configuration is also made so that the electronic components 301 and the electronic component 310 may not interfere with an imaging area of the first line sensor 305 in the similar imaging of the electronic components 301 and the electronic component 310 by means of the second line sensor 311. The first line sensor 305 and the second line sensor 311 are connected to an image processing unit 306 so that information can be transmitted individually and mutually between the line sensors and the image processing unit.

In the component recognition processes, the head unit 303 is moved at constant velocity in one direction, i.e., in X-direction in the component recognition processes

in the fourth embodiment, while the head unit is reciprocated in both the directions X1 and X2 in the third embodiment.

Hereinbelow, operations of a component recognizing method of the fourth embodiment will be described.

Three electronic components 301 and one electronic component 310 are sucked and held by the head unit 303 equipped with four nozzles 302 and the head unit 303 is moved to a start position in a recognition area equipped with the first line sensor 305 and the second line sensor 311.

On the basis of the control by means of a main control unit 307, subsequently, a drive control unit 304 moves the head unit 303 at constant velocity in the X-direction over the first line sensor 305 with heights of the nozzles 302 set at a first focus coincident height fit for the electronic components 301 and the first line sensor 305 images holding status of the electronic components 301 and the electronic component 310.

When these imaging operations are completed, the image processing unit 306 performs recognition processing on the basis of image data of the electronic components 301 and the electronic component 310 which have been imaged.

The drive control unit 304 subsequently moves the head unit 303 at constant velocity still in the X-direction

over the second line sensor 311 with the heights of the nozzles 302 changed to and set at the second focus coincident height fit for the electronic component 310 and the second line sensor 311 images the holding status of the electronic components 301 and the electronic component 310.

The image processing unit 306 performs recognition processing on the basis of image data of the electronic components 301 and the electronic component 310 which have been imaged.

When the recognition of the holding status of the electronic components 301 and the electronic component 310 is completed, the main control unit 307 calculates correction quantities with respect to installation positions in a circuit board on the basis of a recognition processing result obtained from the image processing unit 306. At this time, the main control unit 307 selects out for three electronic components 301 the recognition processing result in which the head unit 303 was imaged by the first line sensor 305, and selects out for one electronic component 310 the recognition processing result in which the head unit 303 was imaged by the second line sensor 311. On the basis of the recognition processing result fit for each electronic component, correction quantities for positional offsets of the electronic components 301 and the electronic component 310 with respect to suction positions of the nozzles 302 are

taken into account, and the electronic components are installed on installation positions in the circuit board.

In accordance with the fourth embodiment, in the component recognizing method in the electronic component mounting apparatus having the head unit equipped with the plurality of nozzles each for sucking the electronic component, the X-Y drive device for moving the head unit to a specified position in the X-Y directions, the vertical drive device for driving vertically the nozzles provided for the head unit, the drive control unit for controlling the X-Y drive device and the vertical drive device, the line sensors for imaging electronic components sucked by the nozzles, the image processing unit for performing recognition processing while controlling the line sensors, and the main control unit for controlling the drive control unit and the image processing unit, the plurality of line sensors are provided and arranged in the X-direction, and in the movement of the head unit in one direction, i.e., in the X-direction over the plurality of line sensors, the nozzles are vertically moved simultaneously for each line sensor so that heights of the electronic components sucked by the nozzles are changed to specified heights over each line sensor, and the electronic components are imaged by each line sensor.

In accordance with the fourth embodiment, a

plurality of line sensors are provided and arranged in the recognition area and, in the movement of the head unit in one direction, i.e., in the X-direction over the plurality of line sensors, component holding heights of the nozzles can be changed to a focus coincident height fit for each group of electronic components having thicknesses different from those of the other groups, over each line sensor by vertical movement of the nozzles, so that effects similar to those of the above-mentioned invention can be achieved.

The present invention can be configured with various aspects in addition to those shown in the above-mentioned embodiments.

For example, the third and the fourth embodiments have been described with reference to the examples configured with the line sensors; however, the embodiments can be implemented in the same way, for example, even if three-dimensional sensors are substituted for the line sensors.

The third embodiment has been described with reference to the example in which two types of electronic components 301 and 310 having different thicknesses are made to go and return two times over the line sensor 305 for the imaging of the components; however, the embodiment can be implemented in the same way, even if the number of times the head unit goes and returns and the number of times the

component holding heights of the nozzles 302 can be changed are increased according to the number of types of electronic components with different thicknesses, for example, even if the head unit 303 is made to go and return three or four times provided a plurality of electronic components having different thicknesses suck and held by the head unit are of three or four types. The fourth embodiment also can be implemented in the same way, even if the number of the line sensors and the number of times the component holding heights of the nozzles 302 can be changed are increased according to the number of types of electronic components with different thicknesses suck and held by the head unit.

The third and the fourth embodiments have been described with reference to the examples configured with four nozzles 302; however, the number of the nozzles is not limited to four but has only to be plural.

When only five nozzles out of ten nozzles 302 are used, for example, the main control unit 307 may be made to control so that only the image data of components held by the five nozzles in use is captured on the basis of information on the use of the five nozzles in use.

In the event that a positioning operation mode according to another embodiment of the present invention as shown in FIG. 28, in which each suction nozzle 302 of a head unit 303 has a nozzle vertical drive motor 302D, is not

capable of bringing a component 301C into a recognizable range (L), for example, beyond a driving range of the nozzle vertical drive motor 302D in contrast to components 301A and 301B sucked and held by the suction nozzles 302 and brought into the recognizable range (L) by the drive of the nozzle vertical drive motors 302D, the components 301A and 301B may be recognized while being moved in one direction with respect to a line sensor 305, and a vertical drive motor 316 may be driven for lowering an L-type plate 318 and all the nozzles 302, changing heights of bottom surfaces of the components and bringing the component 301C into the recognizable range (L), and thereafter, the component 301C may be recognized while being moved in another direction opposite to the above-mentioned one direction with respect to the line sensor 305.

As described above, according to the present invention, components of which surfaces to be recognized have different heights can be continuously recognized by moving the component holding members vertically according to the heights of the surfaces to be recognized of the components in the recognition of the components by means of the recognition unit. This arrangement eliminates the necessity of a plurality of times of repetition of a component recognizing operation according to a variation in the heights of the surfaces to be recognized, allows

components to be held at the same time and allows component recognizing operations to be performed continuously regardless of the heights of the surfaces to be recognized, so that an improvement in component mounting tact time can be achieved.

Besides, the adjustment of the heights of the surfaces to be recognized can be achieved by a single drive unit though, conventionally, the adjustment has required drive units of which the number corresponds to the number of nozzles, and thus the cost and the weight of the apparatus can be reduced.

In addition, the positioning operation can be started accurately and in an inexpensive manner with arbitrary timing, provided that a velocity curve in the vertical movement of the selected component holding member is produced with parameters of a target position in the direction of height at the time when the vertical movement of the selected component holding member is controlled by means of the drive unit so as to position a surface to be recognized of the component within a recognizable range of the recognition unit, a maximum velocity in the vertical movement of the selected component holding member up to the target position, and a maximum acceleration in the vertical movement of the selected component holding member up to the target position, and the positioning operation of the

selected component holding member driven by the drive unit on the basis of the velocity curve is automatically started in response to a positioning operation starting instruction upon the arrival at the positioning operation starting position of the selected component holding member moving transversely toward the recognition unit.

In accordance with the fourteenth aspect of the present invention, the recognition of a plurality of components of which surfaces to be recognized have two different heights can be achieved by moving the component holding members vertically and controlling the heights of the surfaces to be recognized of the components to within a recognizable range of the recognition unit, as occasion requires, by means of a single drive unit for moving the component holding members vertically.

In accordance with the fifteenth aspect of the present invention, a component recognizing method for recognizing components having not less than three different heights can be achieved by moving the component holding members vertically and controlling the heights of the surfaces to be recognized of the components to within a recognizable range of the recognition unit, as occasion requires, by means of a single drive unit for moving the component holding members vertically, on condition that a plurality of sets of parameters of the target positions and

the positioning operation starting positions are provided so as to allow continuous positioning operations to be executed with provision of a plurality of timings.

In accordance with the sixteenth aspect of the present invention, there can be provided a component recognizing method in which whether individual positioning operations in continuous positioning operations which were started at the plurality of positioning operation starting positions have reached positioning operation ending positions or not is judged, i.e., a component recognizing method in which the possibility of recognition is judged by detecting whether the height of an objective surface of each component has been brought into a recognizable range or not.

In accordance with the seventeenth aspect of the present invention, there can be provided a component recognizing apparatus in which the component recognizing method according to the fourteenth aspect is configured accurately and in an inexpensive manner.

In accordance with the eighteenth aspect of the present invention, there can be provided a component recognizing apparatus in which the component recognizing method of the fifteenth aspect is configured accurately and in an inexpensive manner.

In accordance with the nineteenth aspect of the

present invention, there can be provided a component recognizing apparatus in which the component recognizing method of the sixteenth aspect is configured accurately and in an inexpensive manner.

In accordance with the twenty-fourth to thirty-first aspects of the present invention, a plurality of electronic components having different thicknesses sucked and held by the head unit can be imaged at one time and accurately in a series of component recognition processes. As a result, the productivity of component mounting can be increased with a reduction in extra time for the movement of the head unit and the minimization of the occurrence of empty nozzles.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.